PACE Cloud Team Investigators

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Rationale

- Understanding the extent to which the PACE imager can be used to produce relevant and stable cloud products is of *strategic importance to NASA ESD*.
  - Satellite cloud climate data record generation from solar spectral channels is challenging due to the need for exacting reflectance stability over multiple decades.
  - Imager stability requirements for ocean color applications demonstrated to sub-percent level for SeaWiFS using lunar observations. Similar capabilities for OCI defined in the PACE SDT report, in addition to stringent requirements for other radiometric/spectral specifications essential for establishing climate records.

Key Assumption and Scope

1. OCI imager options for cloud/aerosol work that were presented in the PACE SDT report are viable

2. No 3MI polarimeter studies

> "Though our team [*Z. Zhang*] has theoretical and practical experience with polarimetric cloud retrievals, we have not explicitly budgeted for additional studies due to continued uncertainty regarding a PACE polarimeter."

Assumed Viable OCI Imager Options

Table 1. Overview of Ocean Color Instrument (OCI) options and nomenclature used in this proposal. Taken from PACE SDT report, pp. xxii and xxxi.

Imager Option	Instrument Summary
OCI	Threshold instrument. Hyperspectral imager with 5 nm resolution from 350–800 nm. Filter radiometer imager with two NIR channels (one centered at 865 nm) and three SWIR channels at 1240, 1640 and 2130 nm. All channels with 1 km spatial resolution at nadir.
OCI+	The OCI instrument plus three additional spectral channels at 940, 1378 and 2250 nm, all with 1km spatial resolution.
OCI/A	The OCI+ instrument with selected atmosphere channels at 250 m spatial resolution.

Proposal Overview

- Understand OCI/A cloud product information content and retrieval uncertainty vs. VIIRS/MODIS products. Make use of VIIRS/MODIS MODAWG algorithms and NPP Atmosphere SIPS infrastructure.
  - Cloud mask/detection [Lead: *Ackerman*]
  - Cloud-top retrievals w/A-band and 940/1380 nm (OCI+) water vapor bands [Leads: *Heidinger, Meyer*]
  - Cloud thermodynamic phase discrimination information content [Leads: *Coddington, Schmidt, Pilewskie*]
  - Cloud optical thickness and effective particle radius [Leads: *Platnick, Coddington*]
  - Liquid water cloud optical retrieval sensitivity to spatial resolution using obs (eMAS, ASTER) and model (LES) data [Leads: *Zhang, Meyer*]
- Participate with the Project/ST on instrument specs, trade studies, etc. as they pertain to cloud retrievals and information content from OCI(/A) [Lead: *Platnick*]

Potential ST Collaborations

- Detection and impact of thin cirrus on ocean color and aerosol retrievals [Cloud Team Liaisons: *Ackerman, Platnick, Meyer*]
- O_2 A-band studies [Cloud Lead: *Heidinger*]
- Project/ST OCI trade studies w.r.t. cloud products
- Sub-group participation
  - RT/simulations [*Coddington, Heidinger, Platnick*].
    - Cloud team plans include:
      - State variables: previously developed ECMWF ERA-40 land/ ocean, latitude zone climatologies for cloudy profiles
      - A-band: Jurgen Fischer code used for MERIS A-band studies, also LBLRTM
  - Observations (needs to include cloud scenes!)
    - new cloud/aerosol hyperspectral pushbroom imager data from ER-2 in late spring 2015 [Lead: *Platnick*]
    - OCO-2 for A-band obs [Lead: *Heidinger*]

Backup Slides

Table 2. Principle channels for cloud product studies and nominal specifications from the PACE SDT report (pp. xxv and xxxi). Instrument designations for the threshold ocean imager (OCI) and atmosphere options are designated as in Table 1.

Central Wavelength (nm)	Bandpass (nm)	Spatial Resolution at nadir (m)
665	10	1000 [OCI], 250 [OCI/A]
865	40	1000 [OCI], 250 [OCI/A]
763	5	1000 [OCI], 250 [OCI/A]
940	25	1000 [OCI+]
1240	20	1000 [OCI], 250 [OCI/A]
1378	10	1000 [OCI+]
1640	40	1000 [OCI], 250 [OCI/A]
2135	50	1000 [OCI], 250 [OCI/A]
2250	50	1000 [OCI+], 250 [OCI/A]

Table 4. Work plan schedule summary for major activities.

High-Level Activities (refer to proposed efforts in Section 3)	Yr 1	Yr 2	Yr 3
Sect. 3.1: OCI cloud mask algorithm studies (primarily for OCI/A) and quantification of cloud detection skill			
Modify MODIS MOD35 algorithm to run on various OCI instrument options with MODIS and VIIRS providing surrogate observations.	X		
Process months of OCI-like cloud mask data sets for evaluation	X	X	
Analyze OCI-like cloud mask against CALIOP and full MODIS and VIIRS cloud masks. Revise algorithm as needed.		X	X
Sect. 3.2: OCI+ cloud-top pressure height retrieval studies			
Develop/test fast radiative transfer codes optimized for OCI+ A-band and water vapor channels	X		
Develop prototype OCI+ cloud-top OE retrieval code. Compare against existing neural net approaches. Investigate multilayer cloud detection and 2-layer retrieval capabilities.	X	X	X
Test on A-Train observations (OCO-2 + MODIS observations)		X	X
Sect. 3.3: OCI+ cloud thermodynamic phase and optical property information content and retrieval studies			
Develop and generate cloud LUTs needed for OCI+ GENRA analysis. Understand non-retrieved model parameter uncertainties.	X	X	
Thermodynamic phase and optical property information content studies. Optical property retrieval uncertainty studies.	X	X	X
Information content and retrieval uncertainties associated with varying ice habits. Extend GENRA analysis to other tasks.		X	X
Sect. 3.4: Liquid water cloud optical property retrieval sensitivities to spatial resolution and OCI/A requirements			
Determine historical MAS flight tracks suitable for empirical spatial resolution retrieval sensitivity studies. Modify existing MAS retrieval code as needed.	X		
Analyze MAS datasets for range of effective pixel resolutions.	X	X	
Analyze LES model fields for a range of effective pixel resolutions		X	X
Sect. 3.5: Participate in OCI studies (trades, IDL, MDL, etc.) as needed	X	X	X